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THE CENTRAL FORECASTING OFFICE, DUNSTABLE

BY E. G. BILHAM, B.SC., D.I.C.

On February 4, 1940, the Forecast Branch of the Meteorological Office took possession of its war-time headquarters on the outskirts of Dunstable. The decision, that in the event of war the communications centre for the forecasting service should be established in a provincial location, had been made nearly two years earlier. The principal requirement from the communications aspect was that the site should be conveniently placed in relation to the main Post Office land lines. This requirement, in conjunction with other desiderata such as reasonably easy access from London, proximity to a town to facilitate the housing of personnel, and good wireless reception conditions, led to the selection in 1938, of a site on high land (about 500 ft. above sea level) just outside Dunstable.

At a later stage it was decided that, as a war-time provision, the main forecasting centre should be at the same place as the communications centre. Dunstable was therefore planned as a combined forecasting and communications headquarters of the meteorological service. Plans were prepared and were being considered when in the summer of 1939 the threat of war became so imminent that immediate action was necessary. New plans based on the use of standard hutting were quickly prepared and building was begun.

A modern forecasting centre such as Dunstable was planned to be involves, however, a great deal more than the mere provision of roofs and walls, and much still remained to be done when war was declared at the end of August 1939. As a temporary measure, pending the completion of Dunstable, the Forecast Division was evacuated to offices already prepared at Birmingham. This emergency centre was occupied at three days' notice, without disturbing the flow of current synoptic information to outstations.

The move to Dunstable was made under appalling weather conditions and was a complicated operation. A 24-hour service had to be maintained

without interruption, so it was necessary to move the staff by stages, the last contingent travelling by car over roads deep in thawing snow. The change over of teleprinter lines was made between 1500 and 1600 on February 4, 1940. The 1500 reports were dealt with at Birmingham and the 1600 reports were dealt with at Dunstable. It was an outstanding feat in the history of the Post Office Engineering Department and was accomplished without a hitch.

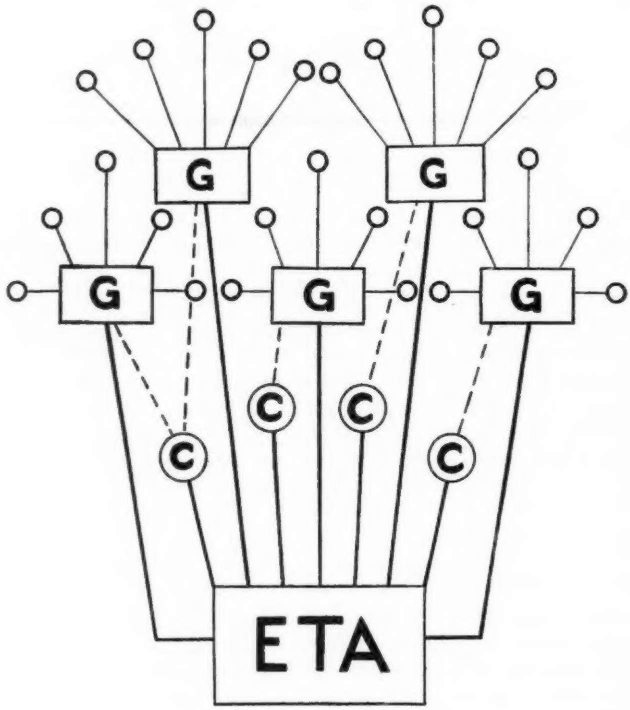


FIG. 1—SCHEMATIC DIAGRAM TO ILLUSTRATE THE ORGANIZATION OF METEOROLOGICAL SERVICES FOR THE ROYAL AIR FORCE

C = Command headquarters

G = Group headquarters

Airfield forecasting units are indicated by small circles

The location of the evacuation centre (at Birmingham) had been kept secret, and it was known by the code name of ETA (the Greek letter η). By the time Dunstable was ready for occupation, everyone had become used to speaking of the provincial headquarters of the Forecast Service as " ETA " and the name was retained for the new station.

To explain the role of ETA in the forecasting organization it is necessary to describe briefly the arrangements which are in operation for supplying the Royal Air Force with weather reports and forecasts. The general

principle is that every important airfield has its own Meteorological Office, which is responsible for the meteorological services needed by aircraft using that airfield. This means that there are a very large number of separate forcasting offices in all parts of the country, in each of which charts are drawn and forecasts are prepared. In general, the forecasting offices also act as weather reporting stations. The normal procedure is to furnish a coded report every hour and to plot a chart every 3 hours, based on observations at the " synoptic hours " 0000, 0300, 0600, 0900, 1200, 1500, 1800 and 2100 G.M.T.

The first obvious necessity for such a service is that there must be a highly efficient network of communications to collect the hourly reports and redistribute them to the forecasting centres, so that all of them may be continuously supplied with up-to-date information for the whole area. The second necessity is a system of co-ordination to ensure that the views as to the main developments of weather expressed by the forecaster at one station will not differ materially from those expressed by the forecaster at another station close by.

Fig. 1 is an attempt to set out the organization diagrammatically. At each operational Group Headquarters there is a Type I Meteorological office which exercises a sort of parental control over a number of subsidiary offices of lower categories. The fundamental analyses and forecasts are originated at the Central Forecasting Office (C.F.O.) which thus furnishes guidance to all the forecasting offices in the system. There are also Type I offices at Command Headquarters, and these are responsible for the general co-ordination of the meteorological services within the Command. Fig. 1 is of course purely diagrammatic and highly simplified. The number of local forecasting offices represented by the small circles actually amounts to some hundreds.

The requirement of a rapid and efficient network of communications is met by the meteorological teleprinter system. The general lay-out of the system is represented by the full lines in Fig. 1. Main lines radiate from C.F.O. to Group offices where they terminate on switchboards. The Group switchboards have connexions to all the stations controlled by the Group, which can thus be put into direct communication with C.F.O. whenever desired. In addition to the main lines to Groups and Commands, C.F.O. also has direct teleprinter lines to the British Air Forces Overseas Headquarters in Germany, the Headquarters of the American Forces in Europe, the Forecast Centres of the French, Belgian and Dutch Meteorological Services, Broadcasting House, the Central Telegraph Office, the Admiralty, etc. (see Fig. 2).

The system for collecting reports works in the following way. Each reporting station in a Group teleprints its coded message to the Group Headquarters where two teleprinters are available to receive them. The Group then compiles a collective message in standard form and teleprints it to C.F.O. At C.F.O. there is a separate teleprinter for each Group in the system, and there is, therefore, no delay in transmission. Connected to each of these teleprinters at C.F.O. there is a " reperforator " which produces a punched tape record of the message at the same time that it is received in typed form. By about 8 minutes past the hour practically all the hourly reports have been received in this way.

Punctually at 10 minutes past the hour, the operator throws the switches on the main panel to the " send " position, and then passes the punched tapes through an automatic transmitter which broadcasts the messages at high speed to all stations. This main broadcast of British and near continental data is completed by the half hour. The remainder of the hour, until H 55 minutes, is occupied with broadcasts of foreign data, upper air data, thunderstorm locations (SFERICS), ships' reports, analyses and forecasts, and special reports of suden changes. This main broadcast to all stations is supplemented by a second broadcast to Groups only.

The teleprinter room, though one of the most interesting features of C.F.O., represents only one side of the communications system (see Fig. 3 facing p. 84). Parallel with the teleprinter room and almost equalling it in size is the wireless reception room, manned by a civilian unit of the R.A.F. (No. 90 Group) (see Fig. 4 facing p. 84). Here are received practically all the meteorological transmissions of foreign data available for the northern hemisphere, as well as direct interceptions of reports from ships at sea and meteorological reconnaissance aircraft. Both rooms of course function continuously day and night. In the adjacent " auto room " transmissions are made continuously by radio channels to overseas and foreign services too distant to be connected to the teleprinter broadcast.

Mention must also be made of the AIRMET radio-telephony broadcasting system which is operated under the joint auspices of the Air Ministry and the Ministry of Civil Aviation. This service, which is the post-war successor to the " Borough Hill " broadcasts of pre-war days functions from 7 a.m. to 10 p.m. in summer, 6 p.m. in winter, and is intended primarily to serve the needs of flying clubs and private fliers using the smaller airfields. The hourly schedule includes navigational warnings, statements of the general weather situation and expected developments, reports of actual weather conditions from selected stations, and talks by the forecaster twice in every hour, in which the weather factors of importance for flying are dealt with in detail.

Dunstable also acts as the control station of the SFERIC service for the location of sources of atmospherics, within a range of 1,500 miles, using a radio direction-finding method. The results which are of great importance in relation to flying operations, and also as an aid to forecasting, are broadcast at frequent intervals on both the teleprinter and radio-broadcasting systems.

In the forecast room (see Fig. 5 backing Fig. 4) surface charts covering most of Europe and the northern Atlantic are plotted every 3 hours, and smaller scale charts are plotted every 6 hours (at main synoptic hours) for an area extending westward as far as the Pacific coast of North America, eastward to the Urals, northward to Spitzbergen and southward to north Africa. For the AIRMET service these are supplemented by large scale charts for the British Isles prepared hourly. Upper air contour charts are drawn every 6 hours for the 700, 500 and 300 mb. pressure levels. Full analyses for the main synoptic hours are made both for the surface and upper air distributions, and prognostic charts are prepared for periods of 24 hours ahead in the case of the surface charts, and 12 hours ahead in the case of the upper air charts. These analyses and

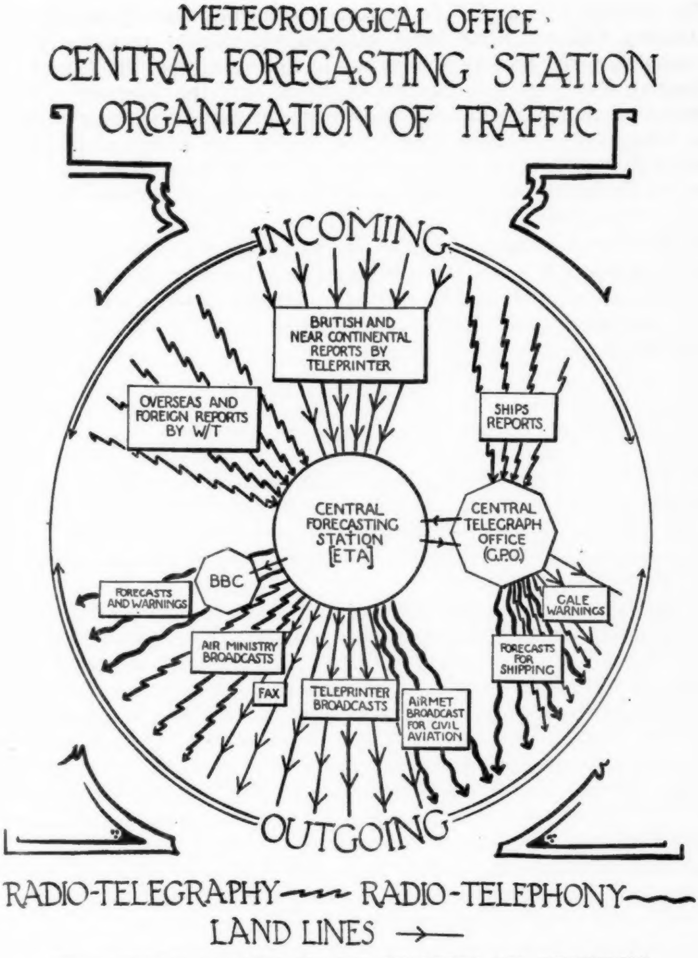


FIG. 2—TRAFFIC CHANNELS FOR THE COLLECTION AND DISTRIBUTION OF INFORMATION AT C.F.O.

Teleprinter, wireless telegraphy and wireless telephony channels are indicated by straight lines, zig-zag lines and wavy lines respectively. FAX is an installation for the direct transmission of weather charts in facsimile by land-line (not at present in operation)

prognoses, together with detailed forecasts for aviation and technical appreciations of the situation are broadcast for the general guidance of outstations in preparing forecasts for local use.

The forecasts and warnings prepared at C.F.O. also include those broadcast by the B.B.C., forecasts for the Press, and a large number of special forecasts, warnings and notifications of specified conditions required by shipping, public services, industrial organizations, and members of the general public.

The installations at C.F.O. include a printing plant operated by H.M. Stationery Office. Four large lithographic presses produce the *Daily Weather Report* which is now issued in three sections, the *British Section* (4 pages), the *Upper Air Section* (4 pages) and the *International Section* (2 pages of charts issued daily and 4 pages of data issued every four days). The lithographic transfers for these reports are prepared by draughtswomen in the forecast room. The C.F.O. printing plant also produces many of the blank plotting charts used in the synoptic service, instrumental charts and marine charts.

In this short account of C.F.O. it has not been possible to describe all its activities in full detail, but it is hoped to publish further articles in which special features such as the AIRMET broadcasting installation will be more adequately dealt with. The first of these, on SFERICS, follows immediately.

SFERICS

BY C. V. OCKENDEN, B.SC.

" Sferic " is the code word which has been used for some years now to designate reports of positions of areas in which thunderstorms are taking place. " Sferic " is derived from atmospheric (the French use " atmos " as the code word), which gives the clue to the basis of the method employed in obtaining the information.

In 1906 in a paper to the Royal Society, Marconi wrote " It would be exceedingly interesting to investigate whether there exists any relation between the direction of origin of these waves and the bearing or direction of distant terrestrial or celestial storms from whence these stray electric waves probably originate ". Twenty years later in the *Meteorological Magazine* for July, 1926, Mr. Bilham reviewed a paper by Watson Watt on " The directional recording of atmospherics " in which it was mentioned that the movement of a trough associated with thunderstorms over Tunis was determined from the directions of arrival of atmospherics at Lerwick, Ditton Park and Aboukir.

To-day in 1946, in the British Meteorological Service, we have regular observations being made 12 times daily by 4 specially selected stations equipped with modern cathode ray direction-finding sets to " fix " the location of thunderstorms with a high degree of accuracy up to a range of 1,000 to 1,500 miles. Several other countries, notably France, America, Germany and Switzerland have for a long time been conducting researches into the various methods for " pin-pointing " atmospherics, and at the recent Conference of the International Meteorological Organization in Paris it was recommended that efforts be directed towards international exchange of " Sferic " reports for the benefit of meteorological services in all countries. It need hardly be said that in war-time the " Sferics " organization was of the greatest importance ; not only did it provide a means of warning those who had to plan 1,000-bomber raids of the existence of thundery activity over the areas in which they were particularly interested, but it kept forecasters primed with extremely reliable information concerning the positions and movements of fronts over enemy-held territory and over sea areas from which weather reports were unobtainable. The

modern " Sferic " sets are costly but maintenance is a relatively small item, and only a few personnel are required to carry out the observations. In view therefore, of the enormous increase in civil flying over long air routes, and the high frequency of accidents attributable to aircraft being involved in cumulonimbus clouds, a Sferic organization is likely to be a very paying proposition in peace-time. Radar methods for storm detection are being developed, but the range of operation is at present less than a tenth of that covered by " Sferics ".

The four stations to which reference has already been made are situated at Dunstable (lat. 51° 53′ N., long. 00° 33′ W.), St. Eval (lat. 50° 28′ N., long. 04° 59′ W.), Leuchars (lat. 56° 23′ N., long. 02° 53′ W.) and Irvinestown (north Ireland) (lat. 54° 29′ N., long. 07° 38′ W.), the " control " station being Dunstable which is also the central forecasting station and communications centre of the Meteorological Office. The fourth station, Irvinestown was only established in 1944, and has been found very useful in checking " fixes " obtained from the other 3 stations, and in enabling good results to be obtained in the event of one of the others being temporarily out of action through technical trouble or a breakdown in communications. At each station there are two huts—one containing the cathode ray direction-finding (C.R.D.F.) equipment, amplifiers, display tube, power packs and so on, whilst the other houses the four fixed vertical frame aerials, or " loops ", two oriented in a true north-south plane and the other two in a true west-east plane. The co-planar frames are connected in series, and with this symmetrical arrangement the mutual induction between the two pairs of loops can be reduced to less than 1 part in 1,000. Precautions are taken to avoid errors through local electrical interference. A photograph of a Sferic set showing the amplifiers, cathode-ray tube and plotting table is shown in Fig. 1 (in centre of this issue) whilst Fig. 2 gives an exterior view of the huts as erected at Dunstable. The receivers are arranged to work on a frequency of about 10 Kc./sec. (30,000 m.) because, although atmospherics can be recorded on practically any frequency, the maximum energy is found between about 8 and 12 Kc./sec. Two other advantages in using this frequency are (1) bearing errors due to polarization are reduced, and (2) this frequency is not much used by commercial W/T transmitting stations. It is possible to tune the sets to stations such as Rugby (16 Kc./sec.), Annapolis (17·8 Kc./sec.), Varberg (17·2 Kc./sec.), etc., and hence obtain a check on bearings found for these fixed transmitters.

The output from the amplifier connected to the N-S frames is fed to the X plates of the cathode-ray tube and that from the amplifier connected to the E-W frames goes to the Y plates. Thus, impulses picked up only on the N-S frames cause the spot of light on the tube to be drawn out into a N-S line whilst a signal received on the E-W frames gives an E-W line. Signals from any other direction will give a line on the tube in an intermediate position dependent upon the resultant of the two deflecting forces, and the direction can be determined to the nearest degree from a graduated circle which is engraved on the glass face. The tubes as used at present have a " persistent " fluorescent coating so that, although the duration of a lightning flash may be only between 1/500 and 1/1,000 second, the afterglow persists long enough for an observer to make an accurate reading

of the bearing. It is hoped soon to make tests with auxiliary tubes, adapted to photograph the flashes on a continuously moving film which can be examined at leisure afterwards and the results compared with the visual observations. No provision is made for determining the " sense " of bearings—there is an ambiguity of 180°, but this is resolved in the plotting operation. The most modern sets are being fitted with a " brilliance modulation " device which secures that the tube is only illuminated for a very short period corresponding to the receipt of the ground wave; polarization errors due to the arrival of waves reflected back from the ionosphere will thus be considerably reduced.

Observations are normally made twelve times daily, each " run " having a duration of 15 minutes commencing at the following (clock) times :—0700, 0900, 1015, 1130, 1220, 1400, 1515, 1630, 1830, 1945, 2100 and 2200.

The four stations are interconnected by telephone tie lines with a switchboard at Dunstable, and the observer at this control station, keeping a constant watch on the tube during a " run ", calls out " now " immediately a flash occurs on the tube which is of sufficient length to enable its bearing to be determined. During periods of great activity flashes may be so frequent that it is not altogether easy to be certain that all stations have identified the same flash, but doubtful cases are weeded out during the plotting process. When a flash is " called " bearings from each station are telephoned in turn to a " Recorder " in the control office who logs them, and at the end of the " run " they are all plotted on a sheet of perspex fixed over an outline map covering an area from the western Atlantic to the Ural mountains and from north Norway to north-west Africa. The map actually employed at Dunstable is an Admiralty chart on a gnomonic projection with point of tangency near the centre of the quadrilateral formed by the 4 observing stations. In general, the bearings do not all intersect at an exact point, but form a small quadrilateral, and the " fix " is taken to be at the centre of this unless there are reasons for believing that more weight should be given to the reading from any particular station or stations. The plotting operation occupies about 5 to 10 min. and on completion, the information is put into a simple coded message for broadcast by teleprinter and W/T. The symbolic form of the Code used for W/T issues is

SFERIC GGGa_1A_1 LLllk LLllk – – – SFERIC GGGa_1A_1 LLllk LLllk etc.

where GGG denotes the time in hours and tenths, a_1 gives an indication of the nature of the distribution of the sources from which activity has been recorded, A_1 gives the probable error of the fix and the degree of activity, whilst the groups LLllk, give latitude and longitude of fixes to the nearest ½ degree. This code has been adopted by America so that no difficulties arise in exchanging reports obtained from their network which comprises C.R.D.F. stations in Bermuda, Florida and New Jersey.

Fig. 3 is a reproduction of the synoptic chart for 1300 G.M.T. on April 11, 1944, on which have been plotted the positions of thunderstorms found by " Sferics " fixes on that day. It will be noted that there were sporadic storms over Britain in the late afternoon in the rear of the occlusion which had reached the North Sea by 1300 G.M.T. and that isolated centres of activity were located just south of the Alps. The most interesting feature

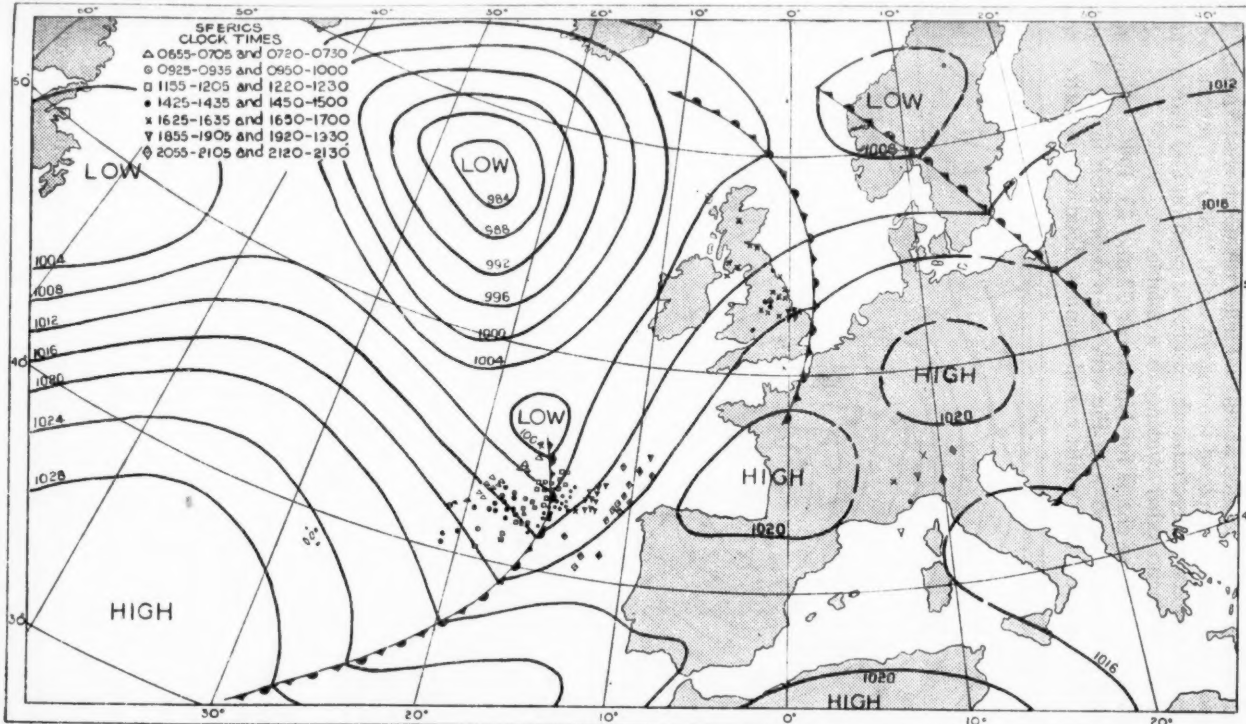


FIG. 3—SYNOPSIS CHART FOR 1300, APRIL 11, 1944
showing positions of storms found by " Sferics " fixes during the day

of the chart, however, is the regular progression of storms associated with the cold occlusion which was moving quickly eastwards along with the secondary depression centred about 500 miles off north-west Spain. The chart forms a good example of the way in which " Sferic " reports can be used by forecasters to determine the probable position and movement of a " front " when no other evidence is available.

Figs. 4 and 5 show charts for November 22 and 23, 1946. Numerous " Sferics " were asociated with the very deep depression in the Atlantic and it is remarkable that whilst cumulonimbus cloud was reported, none

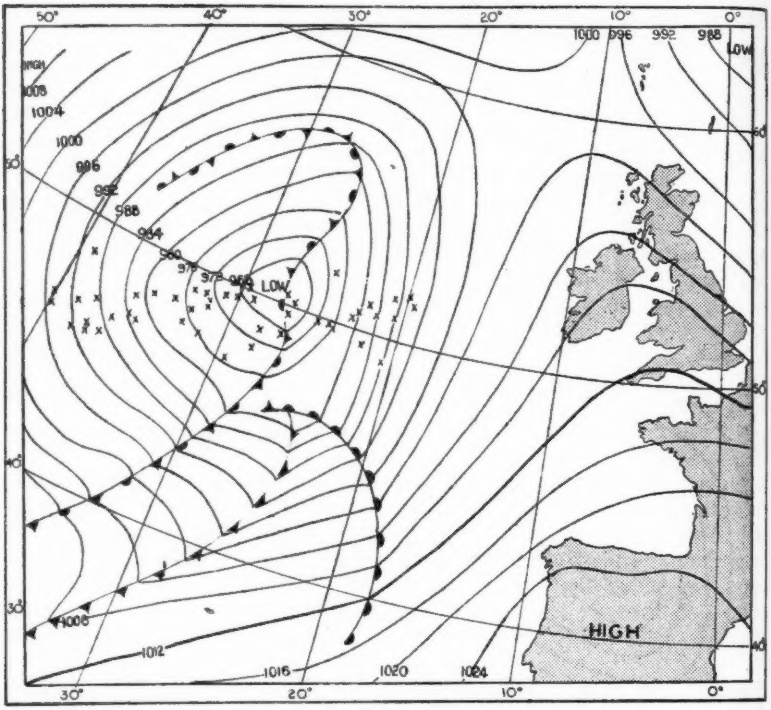


FIG. 4—SYNOPTIC CHART FOR 1800, NOVEMBER 22, 1946, showing positions of thunderstorms found during the day

of the ships' observations gave any indication of actual thunderstorms which were of vital concern to aircraft on the North Atlantic air route. Douglas has pointed out that thunderstorms have a far closer relation with cyclonic vorticity than with any particular kind of air mass, but it is rather unusual to find so much activity not associated with a front as far north on the Atlantic. On the following day, Sunday, November 24, the activity occurred chiefly along a cold front associated with a wave disturbance which moved north-eastwards across the British Isles. The storms were mostly confined to the portion of the front between latitudes 40° and 50° N. as is usually the case, but the north-easterly movement of the main area of activity towards the Brest peninsula and extreme south-

west England is clearly shown on the chart (Fig. 6). Broadly speaking, atmospherics that occur with cyclonic waves appear as rather distinct concentrated and elongated groups travelling with the speed of the wave. The maximum is found at or near the apex of the warm sector, and since very often much Sferic activity is reported even before the wave has developed closed isobars, this is of great assistance in identifying young waves on fronts. In the case of well established cold fronts it is found that there is a maximum of Sferic activity at or immediately in the rear of the front, a minimum between 200 and 300 miles behind the front and a

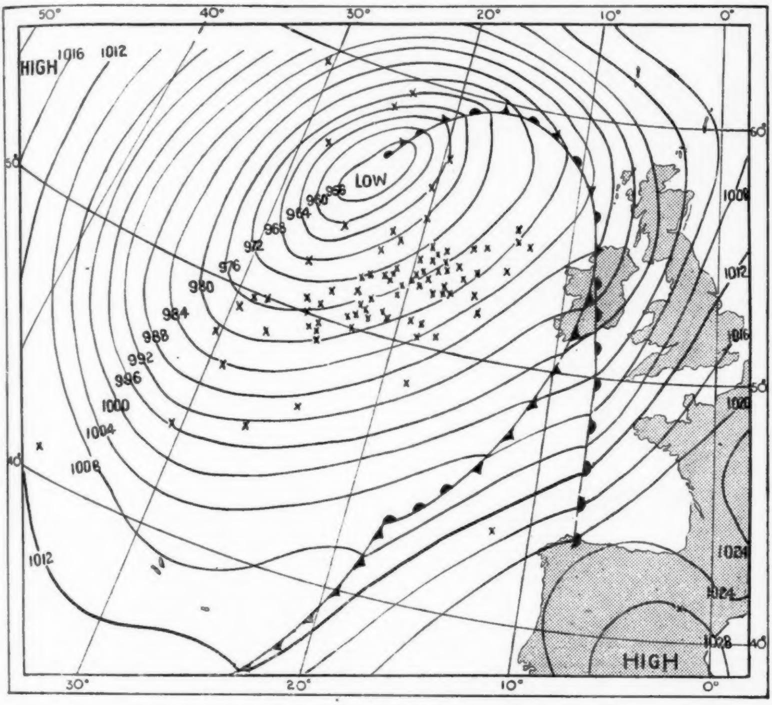


FIG. 5—SYNOPTIC CHART FOR 1200, NOVEMBER 23, 1946, showing positions of thunderstorms found during the day

secondary maximum between 300 and 500 miles within the cold air.

It will be realised that the Sferics organization, whilst it is of the greatest value in giving information regarding the existence and movement of storms which have already broken out, cannot be of assistance in forecasting whether storms will or will not develop and it cannot distinguish between high-level and low-level storms. However, for comparatively short air routes to the continent, Sferic observations are of the greatest use to briefing officers at terminal airports in advising pilots the best route to fly to avoid encountering large banks of cumulonimbus clouds with their associated severe turbulence, icing and " static ". In view of the danger attaching to flying in such conditions and in order to avoid discomfort

to passengers, pilots will be prepared to make considerable detours if by so doing storm areas can be avoided. Successful tests have been made in transmitting " Sferic " charts (as well as " prebaratic " and other charts) by facsimile apparatus direct from the control station to selected receivers, including a despatching airfield, and there is a great future for direct picture transmission which eliminates laborious coding, decoding and plotting; a pilot can be shown the exact " fixes " of any large number of storms just as they have been plotted at the Sferic control station.

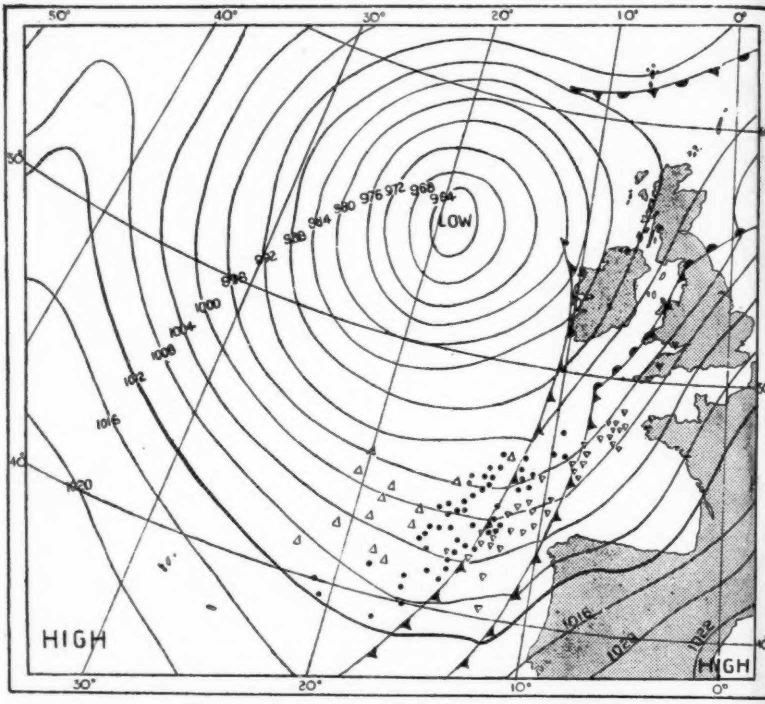


FIG. 6—SYNOPTIC CHART FOR 0600, NOVEMBER 24, 1946
△ indicates fixes obtained between 0700 and 1030
• indicates fixes obtained between 1130 and 1645
▽ indicates fixes obtained between 1830 and 2215

In concluding this account of the Sferics organization as it exists at present, it may be mentioned that plans for the future, besides including photographic recording already mentioned, envisage the use of a spaced-loop aerial system which would reduce polarization errors and enable a 24-hour thunderstorm-location service to be provided. The possibility of measuring the intervals between the time of arrival of successive " echoes " from the ionosphere (as many as 20 have been recorded) is also being considered as a means of calculating the distance of the source; if successful, this would mean that fixing the position of a storm could be done from a single station.

FIG. 3—TELEPRINTER ROOM AT C.F.O.

On these machines hourly coded weather reports from about 400 stations in the United Kingdom and adjacent continental areas are received within 8 minutes of the hour of observation

(see p. 76)

FIG. 4—WIRELESS RECEPTION ROOM AT C.F.O.

(see p. 76)

FIG. 5—IN THE FORECAST ROOM AT C.F.O.
Right, Mr. C. K. M. Douglas, C.B.E., left, Mr. J. Harding
(see p. 76)

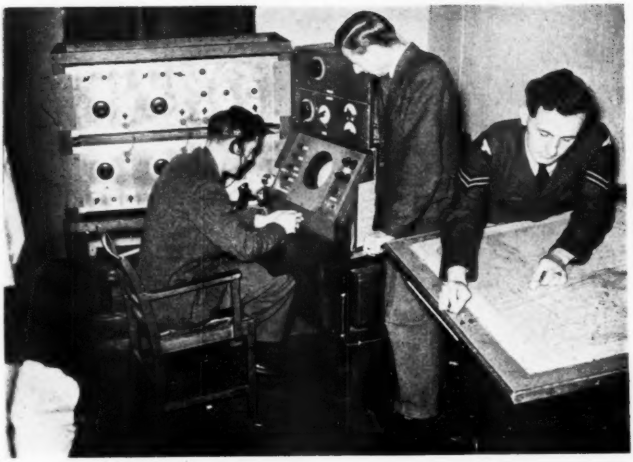


FIG. 1—SFERIC SET SHOWING AMPLIFIERS, CATHODE-RAY TUBE AND PLOTTING TABLE

(see p. 79)

Reproduced by courtesy of "News Chronicle."

FIG. 2—CATHODE-RAY DIRECTION-FINDING HUT AND FRAME AERIAL HUT AT DUNSTABLE

(see p. 79)

A "GLORY" PHOTOGRAPHED FROM A LIBERATOR, JANUARY 25, 1945
(see p. 88)

"CONTESSA DEL VENTO" CLOUD, MILLOM, CUMBERLAND, JUNE 20, 1947
(see p. 88)

METEOROLOGICAL OFFICE DISCUSSIONS

March 31, 1947. Heat transfer by infra red radiation in the atmosphere. By W. M. Elsasser (*Harvard Met. Stud. Milton Mass.*, No. 6, 1942). *Opener*—Dr. J. M. Stagg.

Meteorologists have long awaited a ready means of estimating the contribution made by radiation processes to heat exchanges in the atmosphere and between the ground and the atmosphere. The formation and intensification of temperature inversions, incidence of ground frosts and formation and persistence of fog, and the changes in thermal structure of moving air masses represent some of the practical problems affected to greater or less extent by long-wave radiation transfer. But development of knowledge of the processes involved has been badly hampered by uncertainties about the absorption coefficients of water vapour as the primary radiator, and, to a less degree, by difficulties in handling the equations.

Using the latest information provided by his American colleagues on the absorption characteristics of water vapour in the three main regions of its infra-red spectrum (3 to 8μ, $8{\cdot}5$ to 17μ and above 17μ) Elsasser ingeniously developed a generalised absorption coefficient, which, with a transmission function, allowed him to devise a diagram from which the up and down fluxes of radiation at any level in the atmosphere can be estimated when the vertical distribution of temperature and humidity are known. Absorption by carbon dioxide, the only other important radiator in the lower atmosphere, is concentrated in a narrow band at 15μ and is intense there. A layer in which temperature gradients may be ignored can therefore be regarded as giving a nearly full black body flux at the temperature of the carbon dioxide.

Dr Stagg explained the procedure which Elsasser had followed in building up the generalised absorption coefficients from detailed laboratory measurements and computations based on molecular structure in the rotational band above 17μ, from older and less detailed measurements in the region around 6μ and from estimates based on spectro-heliographic data in the more transparent region between 8μ and 13μ.

Apart from uncertainties in the grafting of each of those regions on to its neighbour, a doubtful factor is introduced in the pressure correction to the absorption coefficients. Spectroscopic theory says that the intensity of line absorption by water vapour should depend on the air pressure but the evidence of laboratory experiments led Elsasser to adopt a correction proportionate to the square root of the pressure.

With the absorption coefficients settled, Elsasser developed an expression for the total radiation flux reaching the ground from the atmosphere in terms of the transmission function, and so it became possible to integrate numerically the equations of radiative transfer. Dr. Stagg showed how the radiation chart is used in typical problems.

In the course of the discussion Prof. Brunt expressed some doubt about Elsasser's method of generalising from line to band absorption and of marrying the laboratory data with those inferred from theory; he emphasised the need for more measurements of long-wave atmospheric radiation. Dr. Robinson said measurements had recently been made at

Kew Observatory and had been compared with estimates made from Elsasser's chart. The chart values could be up to 15 per cent. too high. Using values of long path emissivity of water vapour derived from the Kew measurements, Dr. Robinson had devised a graphical means (based on F. A. Brooks' procedure) of estimating the radiation flux in the atmosphere, which gives values consistently nearer the measured values than those from Elsasser's chart. Mr. Swinbank said that during the course of measurements of changes of temperature and humidity up to 1,500 ft. at Cardington he also had found Elsasser's chart values of radiation too high. Mr. Gold referred to the law of variation of absorption with thickness of the medium and Mr. Sheppard explained F. A. Brooks' technique of deducing radiation values from emissivities : Mr. Belasco described how he had used the Elsasser chart to estimate atmospheric cooling by radiation in two different types of air mass. Dr. Sutcliffe said synoptic meteorologists looked forward to having a ready means of assessing quickly and accurately the magnitude of the effects of radiative transfer in synoptic processes.

In winding up the discussion Dr. Stagg said Elsasser clearly appreciated the weak links in his development and would be the first to agree with those speakers who had stressed the need for more accurate measurements of atmospheric radiation.

LETTER TO THE EDITOR

Rime

In the article on " Rime " in the *Meteorological Magazine* of February, 1947 (p. 45), it is described as " a crystal deposit ", without qualification, and I think most meteorologists think of rime as a crystal deposit.

Seligman in his excellent book on " Snow Structure and Ice Forms " states of rime : " Seen under the microscope it has entirely different external characteristics from those of the hoar deposits. It consists of agglomerations of frozen water droplets which do not exhibit the marked external crystalline structure of hoar crystals, being in the form of minute accretions of ice." Seligman goes on to explain that the deposit is not amorphous strictly speaking and that the ice is not colloidal but crystalline.

Clearly crystals may be formed by sublimation on the frozen drops of rime deposited by the supercooled fog. These drops would soon be at air temperature (or " iced "-bulb temperature), even if their temperature rose to 32° F. when they solidified ; and the vapour pressure in the supercooled fog would be higher than that over ice at the same temperature.

International Meteorological Publication No. 50 which contains a section on the description of hydrometeors by Dr. Bergeron defines " soft rime " as " white layers of ice crystals deposited chiefly on vertical surfaces —especially on points and edges of objects—generally in supercooled fog or mist. On the windward side soft rime may grow to very thick layers of a structure similar to that of hoar frost. This process is probably analogous to that of the formation of soft hail." : and " hard rime "— " opaque, granular masses of ice deposited in the same way as soft rime but in ' wet air ' or wet fog at temperatures below 0°C., thus developing a more compact and amorphous structure than soft rime, analogous to that of small hail."

The "Meteorological Glossary" substitutes "supercooled drizzle" for wet fog in the definition of hard rime.

The definitions in International Meteorological Publication No. 50 clearly require elucidation or amendment because there is no difference between supercooled fog or mist and wet fog at temperatures below 0° C.

E. GOLD

May 15, 1947.

NOTES AND NEWS

Award to Mr. E. Gold

On August 9, 1946, Mr. E. Gold was awarded, by the United States, the Medal of Freedom with Silver Palm.

The presentation was made on March 7, 1947, by Major General Clayton Bissel, Military Attache, American Embassy, at the Chancery of the American Embassy, 14, Princes Gate, S.W.7.

We publish below, a copy of the citation.

"Ernest Gold, British Civilian, for exceptionally meritorious achievement which aided the United States in the prosecution of the war against the enemy in continental Europe, as Deputy Director, Meteorological Office, Air Ministry, from November, 1942, to May, 1945. He was instrumental in setting up a system between his Office and the United States Army Air Forces Weather Service, making possible the successful exchange of information necessary in carrying out the vast air operations from bases stretching from North America to Europe and from Greenland and Iceland to Africa. His aggressive work, tireless efforts and close co-operation contributed in no small degree to the great success of the combined air operations in the European and Atlantic regions."

The Meteorological Association

During the recent war some six thousand volunteers came to lend their help to the British meteorological services. A goodly proportion were women, and whilst many wore Service uniform, others remained civilians. Many friendships inevitably grew up, not only among the war-time volunteers, but also between the volunteers and the regular staff of the meteorological services.

With the end of the war, many felt a desire to maintain their war-time friendships, and a suggestion was made by Mr. Alan Swinstead that something akin to an "old meteorologists' association" might be formed for this purpose. Enquiry revealed that there was likely to be a considerable measure of support for such a scheme, and it was also found that the airwomen meteorologists had indeed already formed an "Ex-Met.-W.A.A.F. Association", with Mrs. Ward as its President.

After much effective spadework had been done by a trio consisting of Prof. Sheppard, Mr. D. C. Lloyd and Mr. W. P. Osmund, a meeting was held at King's College, London, on the evening of April 22, at which well over a hundred people were present. Under the able chairmanship of Prof. Sheppard, the meeting agreed to establish an organization, to be known as the "Meteorological Association", with the twofold object of :—

(*a*) fostering good fellowship among members and maintaining war-time friendships.

(*b*) assisting members to keep in touch with meteorology.

So far as the second of these objects is concerned, it is desired to make it quite clear that the Association is anxious not to compete in any way with the Royal Meteorological Society. On the contrary, the two bodies are regarded as complementary, and their activities as mutually supporting.

Membership of the Association is open to any person who is, or has been, a full-time practising meteorologist, whether as a member of the Meteorological Office staff or of H.M. Forces.

The meeting at King's College approved a set of Rules, fixed the Annual Subscription at 2s. 6d. and elected officers of the Association and a Committee.

The Ex-Met.-W.A.A.F. Association generously expressed their willingness to be incorporated in the new organization, of which the full title is "The Meteorological Association (incorporating the Ex-Met.-W.A.A.F. Association)".

The Committee was given a mandate to arrange the first Annual Reunion in the form of a supper-dance to be held in London in the autumn. Plans to this end are now going ahead, and it is hoped to announce particulars shortly.

All who are interested in the Association are invited to communicate with one of the Secretaries, Mr. N. B. Marshall in the case of men, and Miss Olive Cooper in the case of women. Their respective addresses are—17, Oxford Street, Teddington, and 7, Woodlands Avenue, Finchley, N.3. The formation of a strong and representative Association will also be assisted if readers mention it when next writing to their war-time colleagues.

N.K.J.

A "Glory" photographed from a Liberator

The photograph facing p. 85 was forwarded by S/Ldr. R. A. Buchanan. The photograph was taken at 1400 G.M.T. on January 25, 1945, from a Liberator aircraft based at the Azores. The aircraft was at 5,000 ft. and the height of the top of the stratocumulus was 3,000 ft.

The crew of the aircraft were questioned as to the colouring of the "glory" surrounding the shadow of the aircraft but could only say that the rings were reddish orange. There was no surrounding fog bow.

An unusual cloud formation

The photograph facing p. 85 was contributed by the Meteorological Officer, Millom, Cumberland.

The cloud is the eddy type known as "Contessa del vento" frequently formed to the lee side of isolated mountains. It is often observed over Mt. Etna with a westerly wind. This cloud type was observed at Millom, on the evenings of June 19 and 20, 1944; the photograph was taken on June 20. The synoptic situation on the day was as follows :—

Anticyclone centred west and later north-west of the British Isles. Feeble frontal system moving south-east across north Scotland and the

North Sea. Gradient at Millom, ENE. with air of relatively low humidity and potentially unstable above 700 mb.

By 1900, the easterly gradient having increased, the sea breeze dropped and a land wind resumed with a marked drop in humidity from 72 to 55 per cent. Cumulus dispersed within an hour leaving altocumulus and later the formation illustrated.

The severity of the winter of 1946-7

The following is an extract from a letter received from Prof. Dr. W. Bleeker and Dr. Van den Harn of the Koninklyk Nederlandsch Meteorologisch Instituut, De Bilt, Holland.

"As a result of last severe winter there exists an increased interest in the classification of cold winters among some scientific assistants at our Meteorological Office. To classify severe winters we used a method, called after the German meteorologist, Hellmann, who first applied it to a series of winters in Berlin. It works as follows :—

For each day of the winter the mean temperature is computed from hourly temperature observations. By adding all daily mean temperatures below freezing point one gets the 'characteristic number'. This number gives the degree of severity of a winter. In this country we have a continuous series of temperature observations since 1706, so that we could classify all winters from 1706 up to 1946. The following list shows the results (winters classified according to severity).

	Year	Duration in days	Characteristic number °C.
1.	1789*	87	-359
2.	1942	69	-331
3.	1830	61	-325
4.	1838	48	-320
5.	1795	56	-317
6.	1823	48	-315
7.	1740	75	-313
8.	1845	83	-312
9.	1799	52	-302
10.	1940	73	-300
15.	1891	60	-265
22.	1929	71	-218

* 1789 means winter 1788-1789.

We added two very famous winters of the last 100 years, to show that they did not rank among the ten coldest winters we had in this country.

Last winter reached the second place on the list with characteristic number -343 and a duration of 70 days.

Following details about last winter may interest you. There were three well separated frost periods. The first lasted from December 14 to 25. During 9 days in this period temperature did not rise above freezing point at all. The minimum temperature at De Bilt was 4° F. on December 21. On Christmas Eve there was a general thaw and milder conditions prevailed until January 4, when the second freeze-up began. This time

the frost lasted only 5 days with temperature reaching its minimum (10° F.) on January 7.

It is remarkable that there did not fall any snow during the two first frost periods of this winter. In the middle of January weather became very mild with temperatures rising to 50° F. but then on January 21 the third and longest frost period began. It lasted until March 16. The first important snowfall occurred on February 2. The total snowfall up to the end of the winter is estimated to have been about 15 in. In this winter there were altogether 31 days with temperature below 20° F.

There were 48 ' ice ' days, as we call days on which temperature does not rise above freezing point (maximum below 0° C.). Since 1706 only the winter of 1789 had more ice days, viz. 49. The absolute minimum temperature in this country was observed at Groningen on February 24; it was —1° F.

The month of February was particularly cold, with a mean temperature of -5·5° C. (22·1° F.). As the normal mean temperature for the country is + 2·5° C. (36·5° F.), this month was 14·5° F. too cold.

Recently a new method for classifying cold winters has been developed by Dr. H. ten Kate. He compares the actual temperatures with daily normal temperatures. For every day of the "winter period" the difference between the real mean temperature and the normal mean is computed. As the ' winter period ' does not coincide with the meteorological winter (December 1-March 1) it is necessary to decide which dates are to be considered as the beginning and the end of the period. In every cold winter there is a central part, the main body of the winter, e.g. in 1947 from January 21 until the middle of March but other frost periods may occur, separated from the main body by a thaw. Now it appears reasonable to take these periods into account if two conditions are satisfied :—

(1) the number of frost days must be at least half the number of thaw days, by which it is separated from the main body.

(2) taking the thaw period and the separated frost period together, the mean temperature of the two periods must be at least 2° C. (3·8° F.) below the normal mean.

In 1947 e.g. the main body of the winter may be extended by adding the frost period from December 14-25, as the two conditions are satisfied. So for 1947 the ' winter period ' lasts from December 14 until the middle of March. By adding all differences : normal mean temperature minus real mean temperature, we get a negative sum, which again is called ' characteristic number '.

The winter is classified according to its characteristic number. The classification we get in this way is as follows :—

	Winter period	Characteristic number °C.	Mean difference from normal °C.	Duration in days
1.	1829-1830	-534	-5·5	97
2.	1844-1845	-533	-4·8	112
3.	1813-1814	-504	-4·4	114
4.	1946-1947	-489	-5·3	92
5.	1941-1942	-465	-6·9	67"

[Estimates of the relative severity of winters in this country have generally been made on the basis of the mean temperature of the three winter months December to February. Values of mean temperature at sea level over the British Isles are available since January, 1881, and from these the following winter means have been calculated :—

	° F.		° F.
1895	35·2	1917	36·9
1891	36·1	1940	37·3
1947	36·5	1929	37·9

1895 means December, 1894, to February, 1895.

This method is rather crude, and an alternative was devised based on that used by C. Easton in " Les hivers dans l'Europe occidentale ". This gives equal weight to the mean temperature, the number of frost days (minimum temperature below 32° F.), and the number of ice days (maximum temperature below 32° F.). Writing S for the severity of the winter, T for the mean temperature in degrees Fahrenheit of the months November to March, F for the number of frost days and I for the number of ice days in the same period, T_O, F_O, I_O for the long-period averages of these elements and σ for their standard deviations, we have

$$S = (T_O - T)/\sigma_T + (F - F_O)/\sigma_F + (I - I)/\sigma_I$$

The constants were calculated for Greenwich ; multiplying the terms on the right hand side by 15 to give convenient numbers,

$$S = 9(41 - T) + (F - 45) + 3(I - 4)$$

From 1841 onwards, the indices of the ten most severe winters in London calculated by this method are :—

1891	134	1940	85
1947	133	1895	72
1879	109	1847	70
1855	103	1880	70
1845	89	1942	60

The winter of 1895, though intense, was short, and its index calculated by this method does not take a high place. 1947 is practically equal to 1891 as the most severe winter of the past century in London, mainly by virtue of the long period of maxima below 32° F.

In discussing the winter of 1947 however it has to be remembered that temperature and frost are not the only factors to be considered. The depth and duration of snowfall, and the persistence of easterly winds are also of importance. These factors were examined for England as a whole. In the matter of snowfall, the two most severe winters were 1881 and 1947, followed by 1940 and then 1917 and 1895. 1929 and 1891 were even less notable. In respect of frequency of easterly winds 1947 was far more severe than any other year since 1881. It was followed by 1940, 1917 and 1895, and finally 1929 and 1891.

It is not possible to assign exact numerical values to the factors of snowfall and easterly winds but taking these into account as well as mean temperature and duration of frost, it appears that from at least 1881 onwards 1947 was by far the most severe winter in this country. It was followed by 1895 and 1940 about equal, 1891 only slightly less severe then 1917 and 1881 a long way behind and finally 1929.

We cannot readily go back to 1789, but otherwise the conclusion seems to be that in this country, as in Holland, the winter of 1946-7 was the most severe for at least a century. Ed. *M.M.*]

Temperatures of winter months at Kew Observatory

The two accompanying diagrams show graphically the mean temperatures of different combinations of winter months at Kew Observatory.

In Fig. 1 the horizontal lines show the average mean temperature (mean of maximum and minimum) of each group of months for the years 1906-35. The ends of the columns show the temperature in individual winters ; the deficits in cold winters are indicated by the shaded columns below the line and the excesses of mild winters by the black columns above the line. Fig. 1 (a) represents the three coldest months December to February which meteorologists generally regard as " winter ", (b) refers to January to March, (c) to the four coldest months December to March, and (d) to the five months November to March which with short transitional periods make up the winter half-year.

The winter of 1946-7 shows up as the second coldest since 1871 in diagrams (a) (b) and (c), falling short of 1890-1 as regards December to February and December to March, while in January to March it was just exceeded by 1894-5. Over the whole five-month period however, owing to a mild November, 1946-7 does not show up as exceptionally severe.

Another point brought out in all four diagrams is the group of severe winters from 1884-5 to 1894-5, which far exceed any period of similar length since 1871.

Fig. 2 shows the mean temperatures during the most prolonged and severe cold spells of the past century, and brings out the persistence of winter in 1946-7 (almost exactly paralleled 100 years before) compared with the relatively short intense frost of 1895.

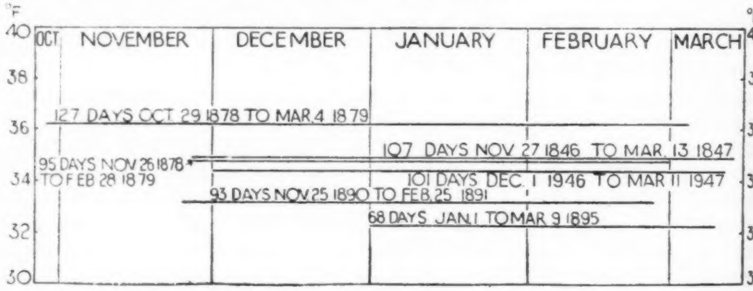


FIG. 2—MEAN TEMPERATURE DURING COLD SPELLS OVERLAPPING CALENDAR MONTHS

All values relate to Kew Observatory except 1846-7 which refer to Greenwich Observatory

Fantastic icicles at Dunstable

We are indebted to Mr. W. Hayes for the sketch on page 94 which shows some of the fantastic icicles up to 5 ft. long that were seen hanging

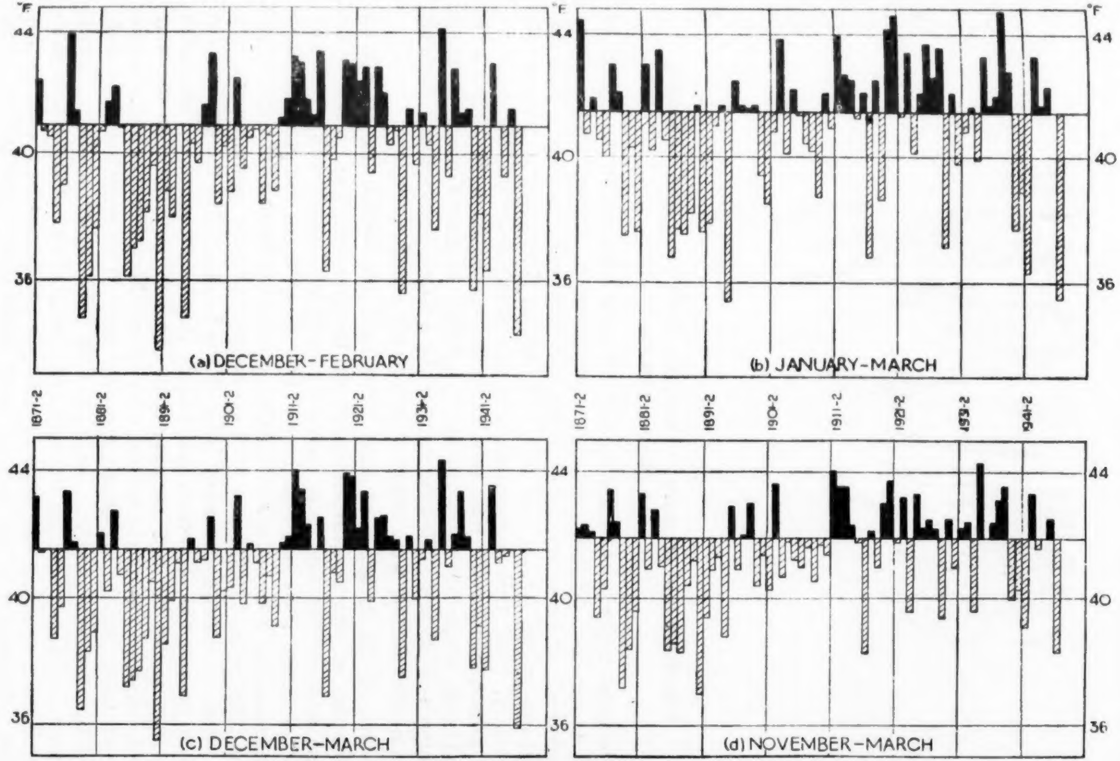
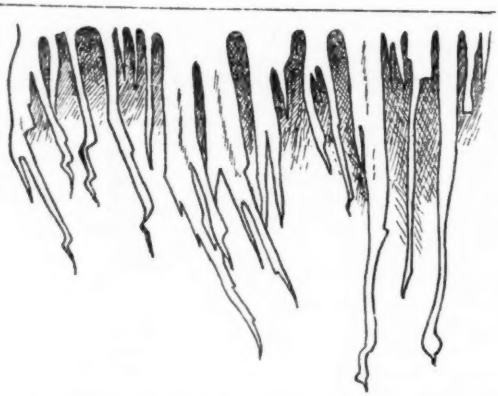


FIG. 1.—KEW OBSERVATORY. MEAN TEMPERATURE WINTER MONTHS
Average temperature (1906-35) given by black line ; mild periods full black areas ; cold periods hatched areas

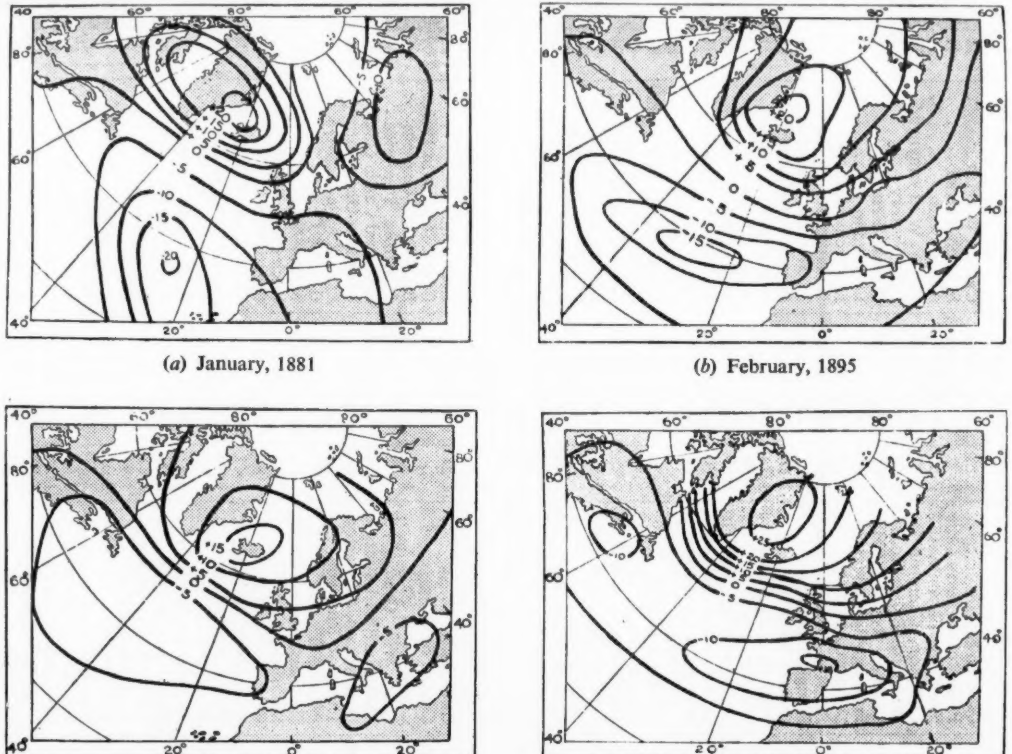
from the eaves of a building at the Meteorological Office, Dunstable, in March, 1947. A strong wind blowing along the building caused the bend in the icicles exposed to its full effect.



Distribution of pressure in February, 1947, compared with other severe winters

In the great majority of winter months pressure is highest in the latitude of the Azores and decreases steadily northwards to Iceland and southern Greenland. In February, for example, the long period average is 1021 mb. at Horta in the Azores and only 999 mb. at Reykjavik in Iceland. In February, 1947, this distribution was completely reversed, the mean for the month being only 1009 mb. at Horta compared with 1023 mb. at Reykjavik, while further north at Myggbukta in East Greenland it was as high as 1035 mb. This means that the westerly winds which normally prevail over Britain were replaced by easterly winds.

Maps of the deviation of mean pressure from normal are often good indicators of the general character of the month. Fig. 1 shows the deviations for the four very severe months of January 1881, February 1895, January 1940 and February 1947. In all cases the greatest excess of pressure lay over Iceland or East Greenland but there were some significant differences. In January 1881 pressure was below normal over almost the whole of Europe, including Ireland and England, but the gradient was not steep and the isanomals ran largely north and south. This month was very snowy but not intensely cold. In February 1895, on the other hand, pressure was above normal over all northern Europe, including the British Isles, and the isanomals ran west-east. This month was intensely cold but not very snowy. January 1940 was rather similar. Finally, February 1947 showed the steepest pressure gradient of the whole series over Britain, agreeing with the great strength and persistence of the easterly winds ; the isanomals run east and west, pointing to severe and prolonged cold, but pressure was below normal over Ireland and England, in accord with the heavy snowfall. The relatively low pressure over England also favoured cloudy weather, cold days but not such intense night frosts as in 1895.



(a) January, 1881

(b) February, 1895

(c) January, 1940

(d) February, 1947

FIG. 1—DEVIATIONS OF MEAN PRESSURE

RAINFALL OF FEBRUARY, 1947

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square	1·55	93	*Glam.*	Cardiff, Penylan	1·75	60
Kent	Folkestone, Cherry Gdns.	1·55	75	*Pemb.*	St. Ann's Head	3·49	125
,,	Edenb'dg, Falconhurst	2·52	114	*Card.*	Aberystwyth	·15	6
Sussex	Compton, Compton Ho.	2·27	86	*Radnor*	Bir. W. W., Tyrmynydd	2·78	53
,,	Worthing, Beach Ho. Pk.	2·04	103	*Mont.*	Lake Vyrnwy	(2·50)	(56)*
Hants	Ventnor, Roy. Nat. Hos.	1·85	88	*Mer.*	Blaenau Festiniog	(1·80)	(22)*
,,	Fordingb'dg, Oaklands	1·15	46	*Carn.*	Llandudno	·92	47
,,	Sherborne St. John	1·46	67	*Angl.*	Llanerchymedd	1·12	44
Herts.	Royston, Therfield Rec.	1·39	90	*I. Man*	Douglas, Boro' Cem.	1·05	33
Bucks.	Slough, Upton	1·12	66	*Wigtown*	Pt. William, Monreith	·78	25
Oxford	Oxford, Radcliffe	1·66	101	*Dumf.*	Dumfries, Crichton R.I.	·99	30
N'hant.	Wellingboro', Swanspool	1·74	108	,,	Eskdalemuir Obsy	1·21	24
Essex	Shoeburyness	·89	72	*Roxb.*	Kelso, Floors	2·20	129
Suffolk	Campsea Ashe, High Ho.	1·69	122	*Peebles*	Stobo Castle	1·61	58
,,	Lowestoft Sec. School	2·30	164	*Berwick*	Marchmont House	2·71	130
,,	Bury St. Ed., Westley H.	1·44	96	*E. Loth.*	North Berwick Res.	1·25	80
Norfolk	Sandringham Ho. Gdns.	1·43	87	*Midl'n.*	Edinburgh, Blackfd. H.	1·44	87
Wilts.	Bishops Cannings	1·24	58	*Lanark*	Hamilton W. W., T'nhill	·80	28
Dorset	Creech Grange	2·73	95	*Ayr*	Colmonell, Knockdolian	·43	11
,,	Beaminster, East St.	1·73	57	,,	Glen Afton, Ayr San.	·94	21
Devon	Teignmouth, Den Gdns.	2·18	82	*Bute*	Rothesay, Ardencraig	·82	21
,,	Cullompton	1·44	52	*Argyll*	Loch Sunart, G'dale	·04	1
,,	Barnstaple, N. Dev. Ath.	·49	18	,,	Poltalloch	·17	4
,,	Okehampton, Uplands	1·62	37	,,	Inveraray Castle	·23	3
Cornwall	Bude School House	1·09	44	,,	Islay, Eallabus	·65	15
,,	Penzance, Morrab Gdns.	2·37	71	,,	Tiree	·18	5
,,	St. Austell, Trevarna	2·17	57	*Kinross*	Loch Leven Sluice	2·92	103
,,	Scilly, Tresco Abbey	5·28	189	*Fife*	Leuchars Airfield	2·17	124
Glos.	Cirencester	1·21	53	*Perth*	Loch Dhu	1·25	17
Salop.	Church Stretton	..	..	,,	Crieff, Strathearn Hyd.	2·89	82
,,	Cheswardine Hall	1·19	67	,,	Blair Castle Gardens	·88	32
Staffs.	Leek, Wall Grange P.S.	·71	33	*Angus*	Montrose, Sunnyside	2·40	130
Worcs.	Malvern, Free Library	1·54	86	*Aberd.*	Balmoral Castle Gdns.	2·42	93
Warwick	Birmingham, Edgbaston	2·01	119	,,	Aberdeen Observatory	1·47	72
Leics.	Thornton Reservoir	1·74	104	,,	Fyvie Castle	2·78	124
Lincs.	Boston, Skirbeck	1·55	106	*Moray*	Gordon Castle	·96	50
,,	Skegness, Marine Gdns.	·89	58	*Nairn*	Nairn, Achareidh	·64	40
Notts.	Mansfield, Carr Bank	2·46	127	*Inv's*	Loch Ness, Foyers	·26	8
Ches.	Bidston Observatory	·81	48	,,	Glenquoich	· 0	0
Lancs.	Manchester, Whit. Park	·41	21	,,	Ft. William, Teviot	·08	1
,,	Stonyhurst College	1·09	33	,,	Skye, Duntuilm	·24	5
,,	Blackpool	· 76	34	*R. & C.*	Ullapool	·50	12
Yorks.	Wakefield, Clarence Pk.	3·27	191	,,	Applecross Gardens	·14	3
,,	Hull, Pearson Park	2·07	185	,,	Achnashellach	·54	8
,,	Felixkirk, Mt. St. John	2·81	166	,,	Stornoway Airfield	·44	10
,,	York Museum	1·91	127	*Suth.*	Lairg	1·65	53
,,	Scarborough	2·05	122	,,	Loch More, Achfary	1·74	26
,,	Middlesbrough	2·37	182	*Caith.*	Wick Airfield	1·43	63
Norl'd.	Newcastle, Leazes Pk.	2·64	173	*Shet.*	Lerwick Observatory	2·67	84
,,	Bellingham, High Green	1·36	54	*Ferm.*	Crom Castle	1·14	39
,,	Lilburn Tower Gdns.	3·83	192	*Armagh*	Armagh Observatory	·65	29
Cumb.	Geltsdale	1·50	49	*Down*	Seaforde	1·46	48
,,	Keswick, High Hill	1·26	26	*Antrim*	Aldergrove Airfield	3·14	46
,,	Ravenglass, The Grove	·87	28	,,	Ballymena, Harryville	1·63	50
West.	Appleby, Castle Bank	1·17	40	*Lon.*	Garvagh, Moneydig	·70	22
Mon.	Abergavenny, Larchfield	2·46	77	,,	Londonderry, Creggan	1·11	35
Glam.	Ystalyfera, Wern Ho.	1·81	35	*Tyrone*	Omagh, Edenfel	1·16	39

* Brackets indicated that the figures are partly estimated